Spillovers and Redistribution through Intra-Firm Networks: The Product Replacement Channel

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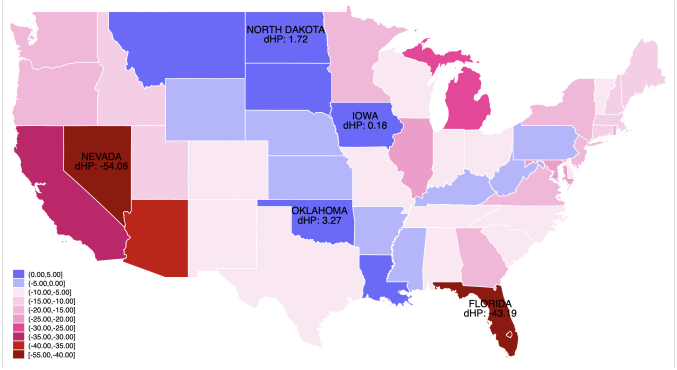
Motivation

Q. How do regional shocks spill over across regions & reshape regional welfare?

- A long-standing question in macro/trade, **relevant in within-county contexts**

  e.g., A sudden differential collapse in local housing markets in Great Recession



State-level Housing Price Growth in Great Recession

$\Rightarrow$ regional conditions spill over through various networks and reshape regional inequality

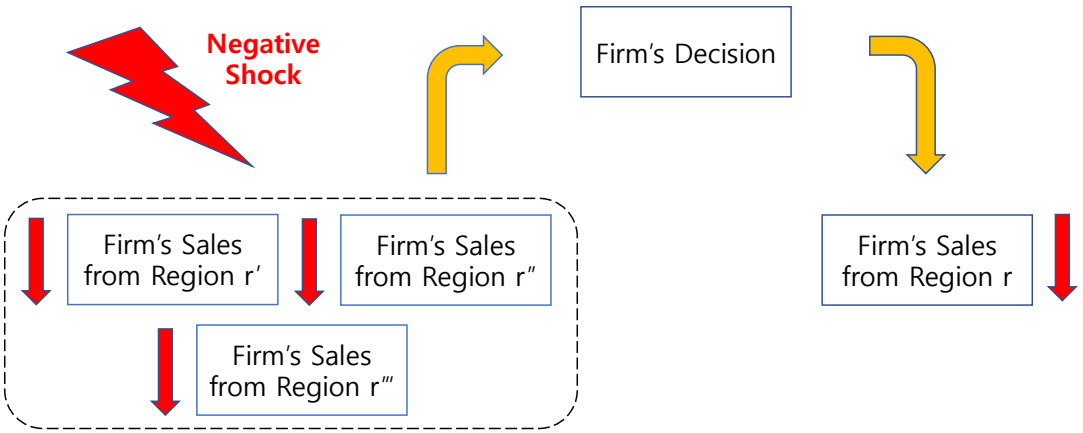
This Paper

- **Intra-firm networks** of producers who sell in multiple counties/states
  $\Rightarrow$ important firms, but ambiguous direction of spillovers
- **Empirics**: provide causal evidence of within-firm regional spillovers and identify a novel mechanism behind
- **Model**: formalize the mechanism & discuss aggregate implications

Summary: Empiric

By exploiting a detailed micro-data including a million of barcodes and producer info. & sudden *differential* $\Downarrow$ in local house prices in 07-09,

(1) Firm's local sales ***decrease*** w.r.t. not only *direct* local demand shock but also firm's average *indirect* local demand shock originating in its ***other markets***

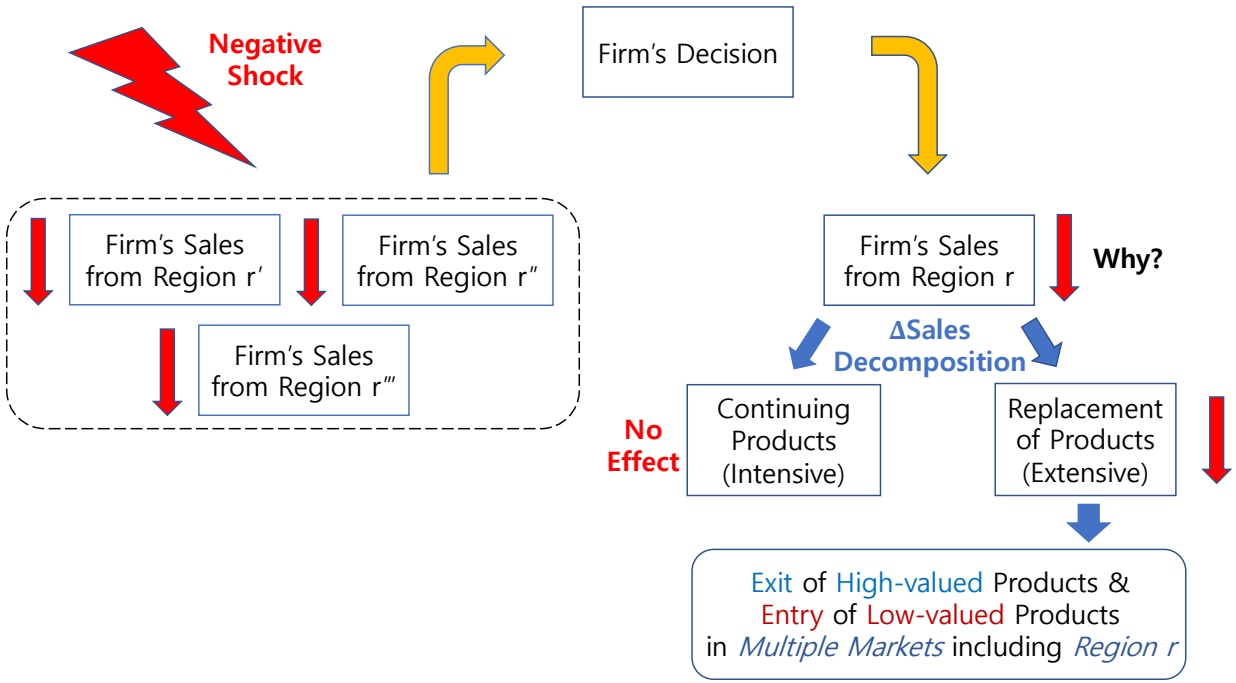


Summary: Empiric

(2) **Why? We show that**

- Such *spillover* driven by *extensive margin response* from product replacement
  (while *direct local shock* ⇒ *intensive margin* from continuing products)

- Product replacements typically *synchronized* across many markets
  - Shocks hitting other mkts induce product replacement even in "not hit" mkt
  - Firms downgrade products (organic→non-organic, expensive→cheap etc.)



Summary: Empirical Results - Some Remarks

1. What are real world examples of synchronized product replacements?

- Kraft Foods Inc. produces both organic and non-organic cheese

(a) Organic Cheese

(b) Non-organic Cheese

- Organic: sold in 11 states in 2007, exited all the states in 2009
- Non-organic: uniformly entered in the same states
- Despite a large variation in regional shocks: -5% (PA) to -23% (MD)

2. We address potential endogeneity concerns in depth

Summary: Theory

Empiric: replacing high- to low- value products, which are synchronized across many markets

(2) **Mechanism**

A. producers facing negative demand shocks lower their product quality
   - because of the (i) scale effect and (ii) non-homotheticity

B. in doing so, they do it in multiple markets simultaneously
   - because of the local-firm-specific fixed cost of product replacement

(3) **Implication**: mitigates the regional consumption inequality

- many regions face the same quality goods: a novel risk-sharing mechanism
- std(consumption growth) $\Downarrow$ by 30% w/ the mechanism, $\approx$ \$400 per HH

◂ Example

Related Literature

Networks, Spillovers, and Macroeconomy

Go Back

- Multi-Market: Berman et al. 15, Ahn & Mcquoid 17, Almunia et al. 18, Erbahar 18
- Multi-Establishment: Carvino & Levchenko 17, Gilbert 18, Giroud & Mueller 19
- Trade & Supply Chain: di Giovanni & Levchenko 10, Acemoglu et al. 16, Stumpner 17, Caliendo et al. 18, Arkolakis et al. 18, Auerbach et al. 19, Boehm et al. 19
- Banking Networks (Acemoglu et al. 15, Gilje et al. 16, Mitchener & Richardson 19); Migration (House et al. 18); Social Networks (Bailey et al. 18)

Housing Market Collapse and the Great Recession

- Mian et al. 13, Mian & Sufi 14, Stroebel & Vavra 19, Kaplan et al. 16, Giroud & Mueller 17, Beraja et al. 19

Variety/Quality Changes & Distributional Implications

- Broda & Weinstein 10, Schmitt-Grohe and Uribe 12, Nakamura & Steinsson 12, Hottman et al. 16 Dingel 17, Jaimovich et al. 17, Argente et al. 18, Jaravel 18, Medina 20, Faber & Fally 20

Business Cycle Comovement

- Backus et al. 92, Frankel & Rose 98, Kose & Yi 06, Johnson 14, Liao & Santacreu 15, Cravino & Levchenko 17, di Giovanni et al. 18

Regional Risk-Sharing/Redistribution

- Asdrubali et al. 96, Lustig & Van Nieuwerburgh 10, Hurst et al. 16

Uniform Pricing in Retail Sector

- DellaVigna and Gentzkow 17, Cavallo 18, Hitsch et al. 19

Empirical Specification

- Data: regional house price + barcode-region level p,q + producer info. data

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf}\ (\text{other}) + \text{Controls}_{rf} + \varepsilon_{rf} \qquad (1)$$

where r: region (county/state), f: firm, $\tilde{\Delta}X$: growth rate of X in 07-09
δ_s: primary sector FE

- β_2: the effect of regional shocks hitting other markets of firm f
  conditional on direct local demand
  - Indirect Shock: $\tilde{\Delta}HP_{rf}\ (\text{other}) = \sum_{r' \neq r} \omega_{r'f} \times \tilde{\Delta}HP_{r'}$
    - Also consider similarly constructed IVs
  - No prior on $\beta_2 \Rightarrow$ We get $\beta_2 > 0$

- β_1: the effect of direct regional shock in region r
  - Similar to Mian et al. (13), Kaplan et al. (16) $\Rightarrow$ We expect $\beta_1 > 0$
  - **Also consider region x sector FE instead of including $\tilde{\Delta}HP_r$**

Key Identifying Assumption

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf\ (other)} + Controls_{rf} + \varepsilon_{rf}$$

Any confounding factor that affects firm's local sales growth does not simultaneously affect its other market house price growth

Threats to identification

- **Common or clustered regional shocks?**

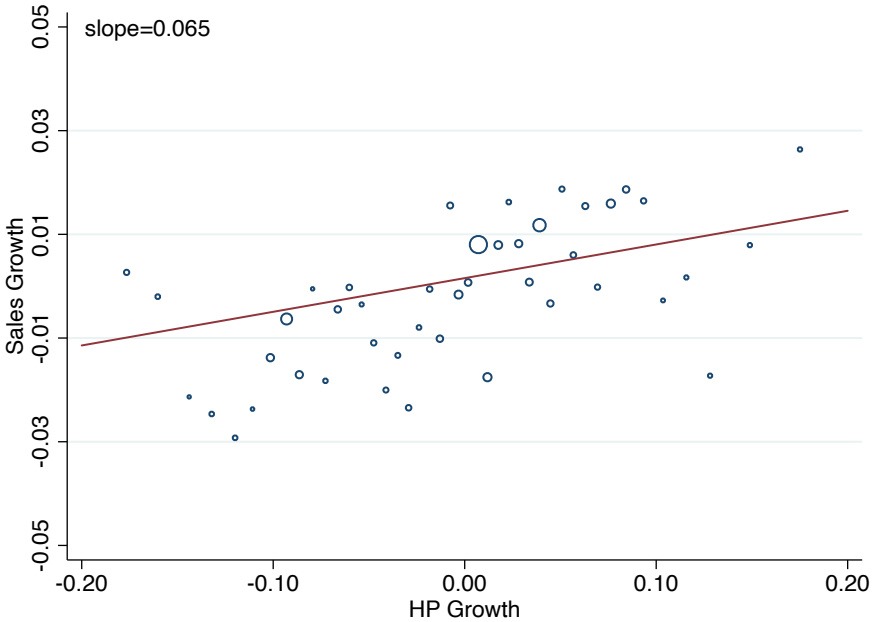
- **Alternative channels?**

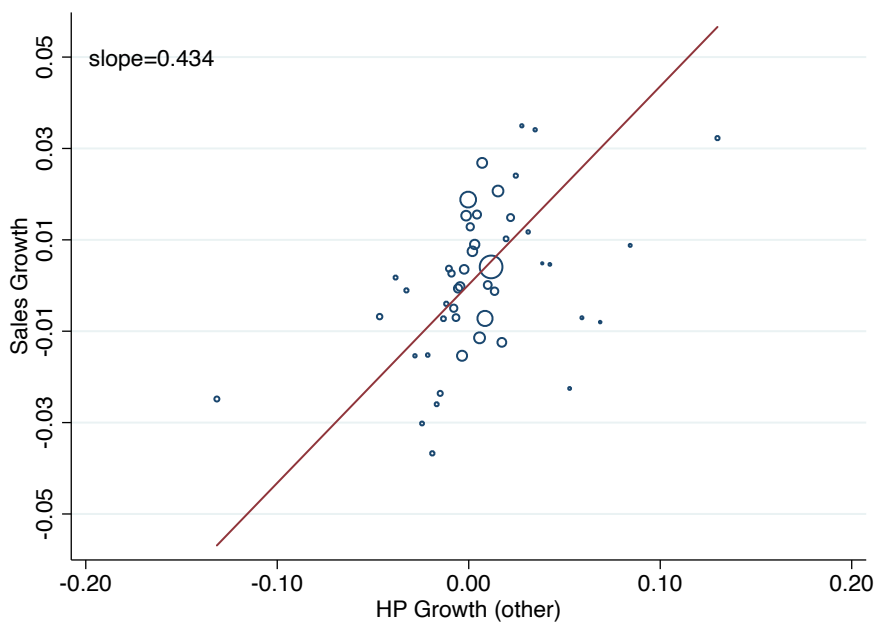
◂ Identification

Visualization

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf}\ (\text{other}) + \text{Controls}_{rf} + \varepsilon_{rf}$$

Local sales respond to both direct and indirect shocks





Scatter plots (25 bins based on ventiles) depicting the relationship between (residualized) $\tilde{\Delta}S_{rf}$ and either $\tilde{\Delta}HP_r$ or $\tilde{\Delta}HP_{rf}$ (other), where each point is the sales-weighted average across obs. within each bin. We use Frisch-Waugh theorem to tease out the effect.

◂ Go Back

Local sales respond to both direct and indirect shocks

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

	(1) $\tilde{\Delta}S_{rf}$	(2) $\tilde{\Delta}S^C_{rf}$	(3) $\tilde{\Delta}S^R_{rf}$	(4)	(5)
$\tilde{\Delta}HP_r$	0.059**	0.051**	0.009		
	(0.028)	(0.024)	(0.014)		
$\tilde{\Delta}HP_{rf}$ (other)	0.345***	0.025	0.320***		
	(0.110)	(0.067)	(0.093)		
sector FE	✓	✓	✓		
county controls	✓	✓	✓		
county-firm controls	✓	✓	✓		
R-squared	0.201	0.223	0.284		
Observations	840,681	840,681	840,681		

Note. County controls : all controls in Mian and Sufi 14. County-firm controls : log initial county-firm specific sales, log initial firm-level sales, log initial number of local markets, and log initial number of product groups. Regressions weighted by county-firm initial sales. Standard errors double clustered at state-sector level.

Direct effect works through the intensive margin

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

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Spillover effect works through the extensive margin

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf}\ \text{(other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

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Spillover effect works through the extensive margin

$\Rightarrow$ robust to county x sector FE

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta}HP_{rf}\ \text{(other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

	(1) $\tilde{\Delta}S_{rf}$	(2) $\tilde{\Delta}S^{C}_{rf}$	(3) $\tilde{\Delta}S^{R}_{rf}$	(4)	(5)
$\tilde{\Delta}HP_{rf}$ (other)	0.398***	-0.021	0.419***		
	(0.105)	(0.045)	(0.102)		
county x sector FE	✓	✓	✓		
county-firm controls	✓	✓	✓		
R-squared	0.392	0.427	0.408		
Observations	840,681	840,681	840,681		

Note. County-firm controls : log initial county-firm specific sales, log initial firm-level sales, log initial number of local markets, and log initial number of product groups. Regressions weighted by county-firm initial sales. Standard errors double clustered at state-sector level.

Spillover effect works through the extensive margin through products replaced in multiple markets

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta}HP_{rf}\ \text{(other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

	(1) $\tilde{\Delta}S_{rf}$	(2) $\tilde{\Delta}S^{C}_{rf}$	(3) $\tilde{\Delta}S^{R}_{rf}$	(4) $\tilde{\Delta}S^{R,M}_{rf}$	(5) $\tilde{\Delta}S^{R,L}_{rf}$
$\tilde{\Delta}HP_{rf}$ (other)	0.398***	-0.021	0.419***	0.418***	0.000
	(0.105)	(0.045)	(0.102)	(0.101)	(0.000)
county x sector FE	✓	✓	✓	✓	✓
county-firm controls	✓	✓	✓	✓	✓
R-squared	0.392	0.427	0.408	0.408	0.216
Observations	840,681	840,681	840,681	840,681	840,681

Note. County-firm controls : log initial county-firm specific sales, log initial firm-level sales, log initial number of local markets, and log initial number of product groups. Regressions weighted by county-firm initial sales. Standard errors double clustered at state-sector level.

Spillover effect works through the extensive margin through products replaced in multiple markets from high- to low-valued products

$$\tilde{\Delta} v_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta} \text{HP}_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

	(1)	(2)	(3)	(4)	(5)
			$\tilde{\Delta} v_{rf} \equiv \frac{v_{rf,09}^{enter} - v_{rf,07}^{exit}}{\bar{v}_{rf}}$		
where v_{rf} =	sale per upc	price	price$^{\text{group-adj.}}$	organic sale	# of upc
$\tilde{\Delta}\text{HP}_{rf}$ (other)	0.52**	0.92**	0.70**	43.78**	-0.06
	(0.21)	(0.44)	(0.34)	(17.88)	(0.17)
region x sector FE	✓	✓	✓	✓	✓
region-firm controls	✓	✓	✓	✓	✓
R-squared	0.40	0.41	0.42	0.38	0.40
Observations	464,423	461,672	461,672	27,930	464,423

Note. For organic share, we use state as a unit of region.

◂ Group Level ◂ Price Reg. (Replacement) ◂ Quality Reg. (Replacement) ◂ Price Reg. (Continue) ◂ Equation

Spillover effect works through the extensive margin through products replaced in multiple markets

$\Rightarrow$ not through simple reduction of variety

$$\tilde{\Delta} v_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta} \text{HP}_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

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◂ Group Level ◂ Price Reg. (Replacement) ◂ Quality Reg. (Replacement) ◂ Price Reg. (Continue) ◂ Equation

Key Identifying Assumption: Further Robustness Check

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf}\ (\text{other}) + \text{Controls}_{rf} + \varepsilon_{rf}$$

Any confounding factor that affects firm's local sales growth does not simultaneously affect its other market house price growth

Threats to identification ◂ Key Identifying Assumption

- **Common or clustered regional shocks?**
  - $\tilde{\Delta}HP_{rf}$(other): exclude nearby counties
  - state-firm-level regression
- **Alternative channels?**
  - supply-side/collateral channel? $\Rightarrow$ $\tilde{\Delta}HP_{rf}$(other): exclude regions with plants
  - not driven by retailer
  - not driven by clientele effect
  - and many others ... ◂ Robustness

Further Results

- **Heterogeneous treatment effect** ◂ interaction

Model Setup

Purpose: Formalize spillover mechanism & discuss aggregate implication $\Rightarrow$

Multi-region model with endogenous quality-adjustments by firms

$\Rightarrow$ **Two key mechanisms** to match the empirical finding

(1) **producers facing negative demand shocks lower their product quality**

- **scale effect: Firms' fixed cost increases with product quality**
- nonhomotheticity : HHs switch from high- to low-quality if income $\Downarrow$

(2) firms choose uniform product quality across markets

- to avoid the local-firm-specific fixed cost of product replacement

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$*$ **Scale Effect:**

◂ Model Setup Details ◂ Structural Eq,

$$\max_{\phi_f, \{p_{rf}\}_r} \pi_f = \sum_r \left[p_{rf} - mc(\phi_f; a_f)\right] Q_{rf} - \left[f(\phi_f) + f_0\right]$$

$\Rightarrow$ scale effect: fixed cost $f(\phi_f)$ increases in intrinsic product quality ϕ_f

Model Setup

Purpose: Formalize spillover mechanism & discuss aggregate implication $\Rightarrow$

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(2) firms choose uniform product quality across markets
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$*$ **Nonhomotheticity:**

◂ Model Setup Details ◂ Structural Eq,

$$U_r = \left[\int_{f \in G_r} (q_{rf} \zeta_{rf})^{\frac{\sigma-1}{\sigma}} df \right]^{\frac{\sigma}{\sigma-1}}$$

(r: region, f: firm, G_r: set of firms selling in market r)

$\Rightarrow \zeta_{rf} \equiv (\phi_f)^{\gamma_r}$: "perceived" product quality of firm f in region r

$\Rightarrow$ nonhomothetic: $\gamma_r \equiv \gamma(\text{Income}_r)$ increases with Income_r

Model Setup

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(2) **firms choose uniform product quality across markets**

- **to avoid the local-firm-specific fixed cost of product replacement**

$*$ **Uniform vs Market-specific Product Quality:** ◂ Model Setup Details ◂ Structural Eq,

$\max_{\phi_f, \{p_{rf}\}_r} \pi_f = \sum_r \left[p_{rf} - mc(\phi_f; a_f)\right] Q_{rf} - \left[f(\phi_f) + f_0\right]$: Uniform

$\max_{\{\phi_{rf}, p_{rf}\}_r} \pi_f^m = \sum_r \left[\left[p_{rf} - mc(\phi_{rf}; a_f)\right] Q_{rf} - \left[f^m(\phi_{rf}) + f_{0r}^m\right]\right]$: Market-specific

Structural Equation: Intra-Firm Market Inter-Dependency

Region-Firm Sales Growth: Scale Effect and Non-homotheticity

$$\tilde{\Delta}S_{rf} = \Upsilon_r \sum_{r'} \omega_{r'f} \left[\tilde{\Delta}S_{r'f} + \tilde{\Delta}(\gamma_{r'} - \xi)\right] + \text{other terms}_{rf}$$

where

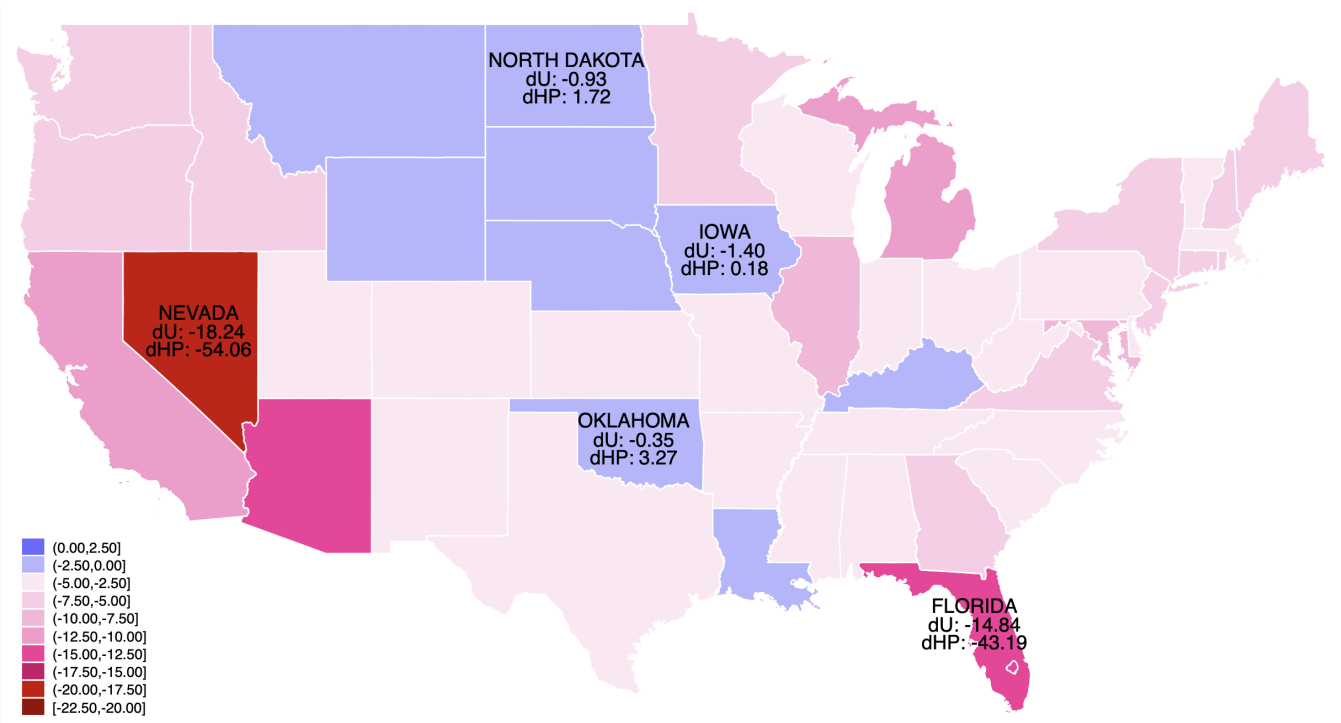
$$\Upsilon_r \approx \underbrace{\beta}_{\text{sales or preference in r' } \Rightarrow \text{ quality of f}} \times \underbrace{(\sigma - 1)(\gamma_r - \xi)}_{\text{quality of f } \Rightarrow \text{ sales in r}}$$

- β: inverse elasticity of fixed cost w.r.t. quality, $f(\phi_f) \equiv b\beta\phi_f^{\frac{1}{\beta}}$
- σ: demand elasticity
- γ_r: how much households value the quality, $\zeta_{rf} \equiv (\phi_f)^{\gamma_r}$
- ξ: elasticity of marginal cost w.r.t. quality (pass-through to price), $mc(\phi_f; a_f) = \frac{\phi_f^{\xi}}{a_f}$

Real Consumption Growth

- **Benchmark**: uniform quality across markets, std$(\tilde{\Delta} U_r) = 4.0$

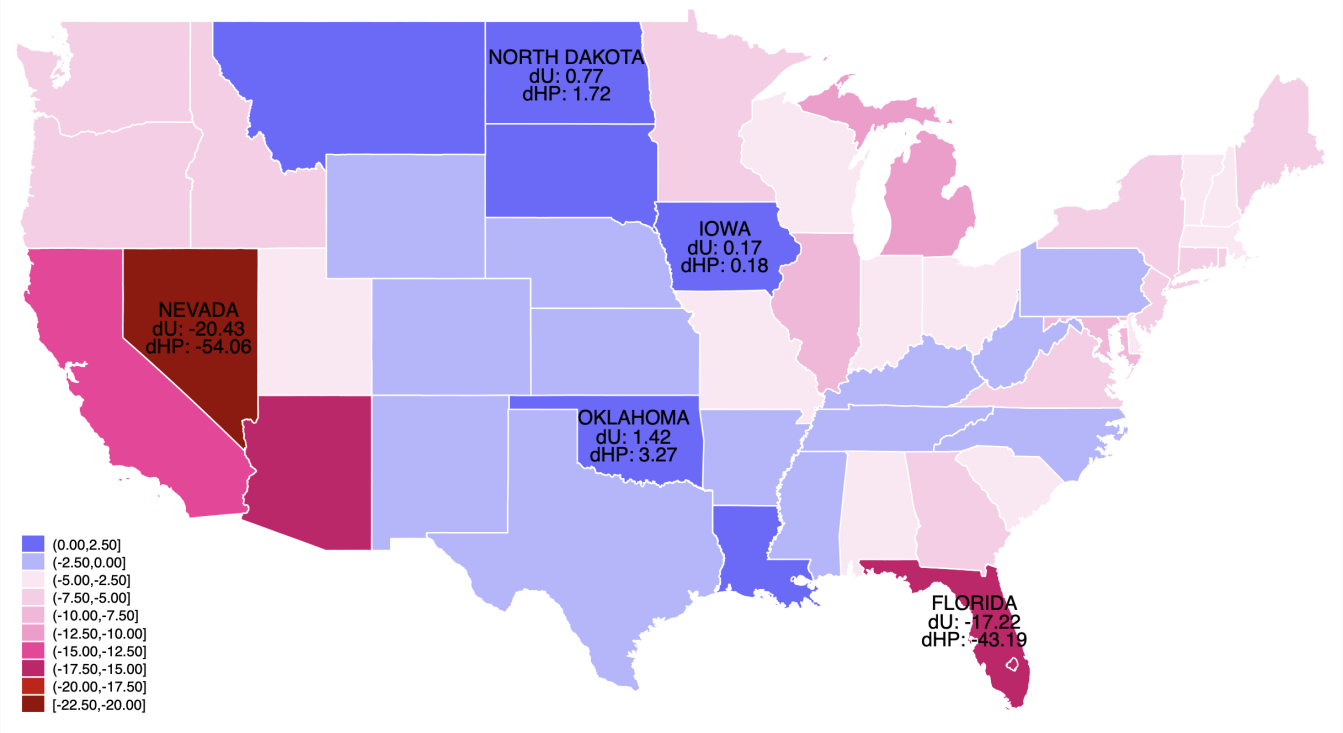
e.g. Florida: real consumption growth = **-14.8%**, house price growth = **-43.2%**
Oklahoma: real consumption growth = -0.4%, house price growth = +3.3%



Real Consumption Growth

- **Counterfactual**: state-specific quality, std$(\tilde{\Delta} U_r) = 5.2$
  - From counterfactual to benchmark: std $\Downarrow$ 30% $\approx$ \$400 per HH redistribution

e.g. Florida: real consumption growth = **-17.2%** (-14.8% in baseline)
Oklahoma: real consumption growth = **+1.4%** (-0.4% in baseline)



◂ More

Conclusion

New Empirical Findings: Regional Spillovers and behind Mechanism

- regional shocks spill over through the intra-firm networks created by multi-market firms
- by replacing high-valued products with low-valued products in multiple markets simultaneously

Model and Implication: Regional Redistribution (Risk-Sharing)

- quality downgrading through product replacement
- mitigates the regional consumption inequality

Thank you!